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Pesticide use in vegetable production in rural Uganda - A case study of Kabale District, South western Uganda

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A study to investigate commonly grown vegetables, commonly used pesticides, and pesticide use practices was conducted in Kabale District, in South-western Uganda. This is because indiscriminate pesticide use and poor application practices can leave pesticide residues in food rendering it unsafe for consumption. The study revealed extensive pesticide application in *Brassica oleracea; var. capitata* (cabbage), *Brassica oleracea; var. botrytis* (cauliflower), *Solanum lycopersicum,* (tomato) and *Beta vulgaris* (beet root). Information obtained using interviews revealed that 16.5% of the traders in Kabale Municipality sold pesticides and 70% of the farmers in the major vegetable growing subcounties of Kaharo, Kyanamira and Kamuganguzi sprayed their vegetables with pesticides. Only 18% of the interviewed farmers could interpret instructions on pesticide container or bag labels correctly. All farmers (100%) had never attended any training on pesticide use. Cypermethrin, dimethoate, dichlorvos, metalaxyl, profenofos, malathion and mancozeb were mentioned as commonly used pesticides in vegetables grown in the district. Some of the farmers (42%) used mixed different pesticides in the vegetables. Limited knowledge about pesticide application, inability to interpret instructions, non-observance of pre-harvest intervals, mixing pesticides and lack of training on pesticide use contribute to pesticide use malpractices which may put farmers' health at risk and reduce food quality. Therefore, there is need to address the identified knowledge gaps on safer pesticide application in order to attain safe agricultural productivity for sustainable food security, safeguarding human health and community development in Kabale District, Uganda.

Key words: Pesticides, vegetables, pesticide use practices, Kabale District, Uganda.

INTRODUCTION

Rapid human population growth has increased food demand worldwide (Jallow et al., 2017) requiring agricultural intensification (Majeed, 2018); however; food loss due to pests is still a challenge (Zanella et al., 2012; Munawar and Hameed, 2013). Pests destroy 30 - 48% of world's food yields annually; for example, in 1987 one third of the potential world crop harvest was lost to pests (Tano, 2011). Crop yield loss is a food security threat (Munawar and Hameed, 2013) which is further enhanced by pests and pathogens. To reduce the food loss as a

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result of pests, chemical pesticide use has been intensified; although, indiscriminate pesticide use can harm humans and the environment (Majeed, 2018).

Indiscriminate chemical pesticide use or haphazard application in food crops may lower food quality, reduce yields, risk consumers' and farmers' health, and affect prices, in addition to polluting the environment. Thus, pesticide use malpractices may reduce the contribution of food production to gross domestic profit (GDP). Proper pesticide application practices and reduced chemical pesticide use is beneficial to everyone and the environment (Bon et al., 2014). Hence, there is need for proper regulation of pesticide use and caution about malpractices.

Non-chemical pest management methods such as biological and mechanical control (nets and traps) have shown promising results in various studies from African countries (Bon et al*.,* 2014; Vidogbena et al*.,* 2015). However, a knowledge gap about their use and efficacy still exists especially in small scale farming; for example, in small scale vegetable production; thus farmers still heavily rely on the use of chemical pesticides for control of pests.

Pesticides are generally described as insecticides e.g. organophosphates, organocarbamates, organochlorines, pyrethrins and pyrethroids; fungicides for example thiocarbamates and dithiocarbamates (Fouche et al*.,* 2000; Fait et al*.,* 2001; Fenik et al*.,* 2011). In vegetable production, different pesticides can be used depending on plant species and pests (Schwinn, 1988; Özkara et al*.,* 2016). Some of the commonly grown vegetables across Africa include bottle gourd (*Legenaria vulgaris*), cabbage (*Brassica oleracea var. capitata*), cauliflower (*Brassica oleracea*), carrot (*Daucus carota*), egg-plant (*Solanum aethiopicum*), spinach (*Spinacia oleracea*) and tomato (*Lycopersicon esculentum*) among others (Ogwu et al., 2016). Similarly, commonly used pesticides in vegetables worldwide include dichlorvos, cypermethrin, malathion, profenofos and metalaxyl among others (Fenik et al. 2011). According to Oesterlund et al. (2014), frequently used pesticides in Uganda belonged to World Health Organization (WHO) class II.

There is widespread pesticide use in most developing countries (Alavanja, 2009; Popp et al*.,* 2013); however, indiscriminate application raises concern over food safety (Perez et al*.,* 2015). Health consequences of excessive pesticide use on consumers' and farmers' safety and the environment require governments to revise pesticide residue standards in food stuffs (Okello and Swinton, 2011). Pesticide use malpractices are a food safety challenge; for example, farmers may not always follow appropriate pesticide use methods like pre-harvest intervals (Miah et al*.,* 2014); yet there is limited information on pesticide use practices in developing countries in sub-Saharan Africa for example in Uganda. Poor pesticide use practices may be attributed to lack of knowledge about the side effects of pesticide use and failure to follow instructions on pesticide usage (Bon et al*.,* 2014). Common malpractices include use of unregistered pesticides, inappropriate dosage, non-compliance to pre-harvest intervals, use of banned pesticides, inappropriate application techniques, pesticide/crop mismatch, use of a mixture of different pesticides in a single spray, insufficient personal protection equipment and unsafe pesticide handling practices (Ngowi et al*.,* 2007; WHO and IPCS, 2010; Naidoo et al*.,* 2010; Marčić et al*.,* 2011; Nonga et al*.,* 2011). While information on pesticides use in Uganda is limited, most farming is done by small-scale farmers on a few acres of land per household often without appropriate application of pesticides (Salameh et al., 2004; Jors et al*.,* 2006). In the absence of appropriate handling of pesticides, the health of farmers and that of their families are at risk (Macfarlane et al*.,* 2008; Sam et al*.,* 2008; Williamson et al*.,* 2008).

In various African countries an average of 10 % of the food budget is spent on fruits and vegetables (Joosten et al., 2015). Vegetable consumption ensures adequate dietary supply of vitamins, minerals, water, and dietary fibre (Sinyangwe et al., 2016). An adult is recommended to consume 400 grams of vegetables daily for a healthy life (Smith and Eyzaguirre, 2007; JICA, 2016). To cope with the increasing vegetable demand, pesticides are used to increase productivity, protect nutritional integrity, facilitate storage to ensure year-round supplies, and provide attractive vegetable products (Chow, 2016). Therefore, this study investigated commonly grown vegetables, common pesticides used in vegetables, attitudes of farmers and traders on pesticide use and application practices in Kabale District, Uganda.

MATERIALS AND METHODS

Study area description

Kabale District is a highland district of Uganda in the South West of the Republic of Uganda. It is bordered with districts of Rubanda to the West, Rukiga in the North and East and the Republic of Rwanda to the South (Figure 1). Kabale District is 402 km from the capital city Kampala, lying between 29° 45' and 30° 15' East longitude and 1° 00' and 1° 29' South of latitude (Langan and Farmer, 2014). The district has an estimated population of 212, 506. Out of these, only 49, 667 (23 %) stay in the municipality and the remaining 162,839 (77%) stay in the rural area. The people are predominantly from Bakiga tribe and a few Batwa (pigmies), Banyarwanda and Bahororo tribal clans. It is one of the most populated districts with projected population density approximated to be at 358 people per Km^2 (Uganda Bureau of Statistics, 2014). Kabale District comprises Kabale municipality (Northern Division, Central Division and Southern Division) and seven sub-counties including Rubaya, Kamuganguzi, Buhara, Maziba, Kaharo, Butanda and Kitumba (Figure 1).

Determination of sample size for interview

The study populations were composed of pesticide traders from

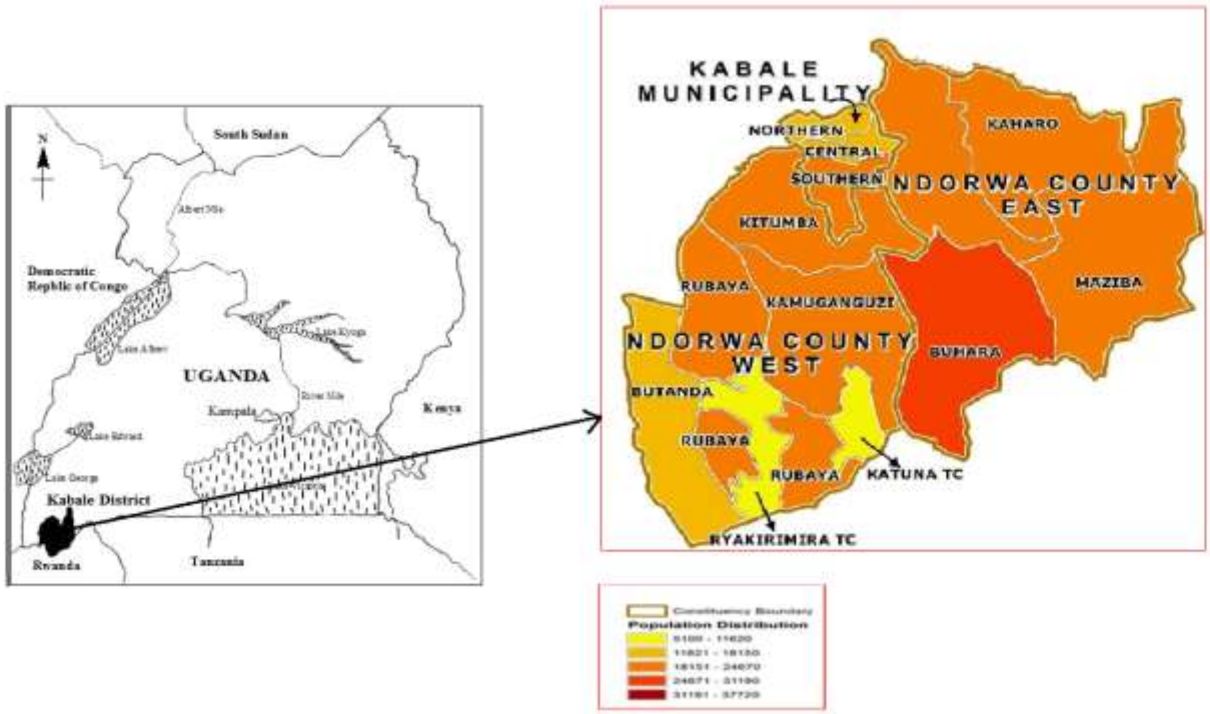

Figure 1. Study area.

Table 1. Number of Vegetable farmers in Kyanamira, Kaharo and Kamuganguzi Sub counties.

Sub-county	Estimate farmers
Kyanamira	4,292
Kaharo	4,064
Kamuganguzi	4,337
Total	12,693

Kabale town, the main commercial area and vegetable farmers from the district. According to Kabale District Agriculture Office the three sub-counties of Kaharo, Kyanamira and Kamuganguzi (Table 1) have majority of the vegetable farmers and they were selected for the study. Therefore, pesticide traders who operated from central market in Kabale Municipality and vegetable farmers in Kaharo, Kyanamira and Kyanamira sub-counties were interviewed in the survey. The sample sizes were determined using Krejcie and Morgan's Table (Krejcie ad Morgan, 1970) in both cases as shown in Table 2. Standardized interview questions were designed for both traders and farmers to ensure homogeneity in responses, that is, traders and farmers were asked predetermined questions related to pesticide use in vegetables grown in the district and their responses were recorded.

Determination of commonly grown vegetables, pesticide used and pesticide use practices in Kabale District, Uganda

This study was designed as a cross-sectional survey on vegetables grown; pesticides used in the vegetables and associated pesticide use practices in Kabale District, Uganda. The study was conducted using face-to-face interviews with traders and farmers. Data were collected based on responses to the interview questions which were designed in English, a language understood by majority of the traders but translation was done to *Rukiga language* for farmers who did not know English. The survey was conducted in April 2017. Pesticide traders considered in the study operated from central division where majority of the shops and central market were located in Kabale municipality.

The active ingredients present in the pesticides were determined by reading their names and quantities on the pesticide container labels. Respondents were interviewed on commonly grown vegetables, pesticides sprayed in the vegatables, the importance of pesticide use in vegetables, known adverse effects of pesticides, ability to interpret instructions on container labels, pre-harvest application intervals, pesticide mixing and trainings on pesticide use attended.

Data analysis

Responses to interview questions such as types of vegetables grown and sprayed, pesticides sold, pesticide use practices and

Table 2. Krejcie and Morgan Table

N	S	N	S	N	S
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

N is population size, S is sample size
Source: Krejcie and Morgan, 1970

effects were collected and tabulated. Frequencies of occurrence were determined using descriptive statistics. Active components of pesticides listed on labels were also tabulated and their frequency of occurrence was determined.

RESULTS AND DISCUSSION

Number of participants in the survey

The number of pesticide traders interviewed during the survey as per Krejcie and Morgan's Table (Krejcie ad Morgan 1970) was 200 out of total of 416 traders who operated in the central market in Kabale municipality. The number of vegetable farmers interviewed was 400 out of 12,693 farmers found in the three sub-counties of Kaharo, Kyanamira and Kyanamira (Table 1). Therefore, 200 traders and 400 farmers were selected at random and interviewed. These numbers provided a representative sample from which data was collected.

Commonly grown and pesticide sprayed vegetables in Kabale District, Uganda

The commonly grown and sprayed vegetables by the farmers in Kabale District are indicated in Table 3. Tomatoes appeared most frequently followed by cabbages, cauliflower, beetroot carrots and green pepper, egg plants. African egg plants and onions had the lowest frequency. These vegetables have a high demand for home consumption and sale.

Common pesticides sold and their active ingredients

The results obtained revealed that 33 traders (16.5 %),

Table 3. Commonly grown pesticide sprayed vegetables.

Types of vegetables	Frequency of occurrence based on farmers' responses
Tomatoes (*Solanum lycopersicum)*	360
Cabbages *(Brassica oleracea; var. capitata)*	244
Cauliflower (*Brassica oleracea; var. botrytis)*	168
Beet root (*Beta vulgaris)*	96
Carrots (*Daucus carota*)	60
Green pepper (*Piper nigrum L*)	60
Egg plants *(Solanum melongena)*	36
African egg plants *(Solanum aethiopicum)*	36
Onions *(Allium cepa)*	24

Table 4. Pesticide types present in shops and their active ingredients (a.i).

Pesticide class	Trade names	Amounts of a.i in each pesticide Kg^{-1}	Total frequency
Fungicides (systemic)	a, b, c, d, e,f, g	Mancozeb 640 g per.Kg^{1} + Metalaxyl 40 g per Kg	Fungicides (352)
	Osho mistress	Mancozeb 640 g.Kg^{-1} + Cymoxanil 80 g.Kg^{-1}	
Fungicides (non-systemic)	i,ii, iii, iv, v, vi vii.vii	Mancozeb 80%	
Insecticides (systemic)	α , β, γ	Dimethoate	
	A	Cypermethrin 4% + profenofos 40%	
	B	Cypermethrin 5%	
Insecticides	C	Cypermethrin 5%	Insecticides (400)
(non-systemic)	Dichlorvos	dichlorvos 100%	
	Malathion	Malathion 50%	

Trade names: Systemic fungicides: a, Ridomil; b, Eureka; c, Victory, d, ^{TATA}Master; e, Kingmill, f, Milraz; g, Osho Master; Non-systemic fungicides: I, Unizeb; ii, Mancodoze; iii,Mancozeb; iv, Sicozeb; v, Tridex; vi- Mancoera; vii, Oshothane; Systemic insecticides: α, Uthoate; β, Tagfor; γ, Sicothoate; Non-systemic Insecticides: A, Rocket; B, Supacyper; C, Cyperlacer.

out of the 200 traders originally selected for the survey, sold pesticides in their shops in Kabale District, Uganda. The common pesticides sold for use in vegetables belonged to two categories namely: insecticides such as pyrethroids, organochlorines, organophosphates and carbamates (53 %) and fungicides (47 %) as shown in Table 4. The findings of the study are in agreement with the results obtained by Ngowi et al. (2007). While some pesticides used in vegetables had different trade names, which could potentially confuse customers; the active ingredients present were similar and the most commonly used active ingredients either singly or in a mixture were mancozeb followed by metalaxyl, dimethoate, cypermethrin, dichlorvos, malathion and profenofos, respectively as shown in Table 4. It was also observed that majority of the pesticide container labels showed percentages of the active ingredients present but the percentage of dimethoate was missing on the container labels. This may affect proper application, thus manufacturers can be engaged to label more appropriately to provide farmers with correct information.

Application of pesticides to vegetables and pesticide use practices

During the interview, it was found that for those farmers who followed pesticide application guidelines, the pesticide was dissolved in water as per the guidelines of the manufacturer and sprayed using a knapsack sprayer. Various sprayers were used but the most common was the Bomba magoba, 10 - 20 L (China), distributed by Chemical Industries Limited, Kampala, Uganda.

Pesticides used in vegetables are commonly delivered in form of droplets from sprayers of different types of nozzles and spray bombs. Spray droplets need to be uniformly distributed on a target surface with minimum losses due to drift, evaporation or run-off in order to maximize spray efficiency. Poor spray application techniques may cause reduced pest control, yield reduction, wasted pesticides and lower returns to the grower. Thus, knowledge about droplet sizes, droplet density and water volume may lead to higher spray efficiency.

However not all farmers could read and interpret instructions on pesticide container labels. About 82% could not interpret instructions on labels of pesticide containers and only 18 % could easily follow instructions given on the pesticide container labels. This demonstrates the need for training and simplifying procedures on the labels so that they are easily understood. This challenge can further be addressed though publication of simple pictorial guides to help semi-illiterate farmers to avoid wrong reconstitution and application practices. Since haphazard pesticide application is detrimental, it is important to provide more farmer education for example to know when systemic pesticides non-systemic pesticides should be used, or when fungicides, insecticides or other pesticide categories are required depending on the mode of infection, pest and plant species.

Post spray waiting periods were haphazard, for instance, about 17.5% of the farmers harvested vegetables 1 h after pesticide spraying, 21% of the farmers after 3 h, and 32.5% after 6 h. 41.8% waited after 1 day of pesticide spraying to harvest vegetables, 4% waited 2 days while only 2 % of the farmers harvested vegetables after 3 days of pesticide spraying. Longer waiting period may allow pesticide degradation to less toxic levels. Non adherence to the pre-harvesting period waiting periods can be associated with accumulation of pesticide residues in vegetables. Therefore it is important to observe an adequate waiting period; moreover, many pesticides are systemic (Miah et al*.,* 2014). Harvesting vegetables after spraying on the same day is wrong – usually at least 3 days or more are needed depending on the vegetable type and pesticide used.

Farmers' responses showed that 42% mix different pesticides before use and 58 % do not mix pesticides. Some farmers mix two or more pesticides with a range of products having the same active ingredients in the same spray tank aiming at increasing efficacy. Similar practices were reported in Tanzania (Ngowi et al*.,* 2007; Mhauka, 2014); however, this is not recommended. Mixing of pesticides in the same spray tank can result in synergistic or antagonistic effects which are not well investigated. Pesticide mixtures can affect plant health, reduce yield and result in multiple pesticide residues in vegetables (Ngowi et al*.,* 2007; Moshi and Matoju, 2017) which can cause various health hazards in humans as well as high production costs. Furthermore, codes of best practices prohibit use of a mixture of pesticides unless advised by the manufacturer or inherent in the formulation (Ngowi et al*.,* 2016; Lekei et al*.,* 2014). Generally, pesticide mixing is one form of pesticide misuse that may lead to application of pesticide sprays with far higher concentrations of active ingredients than what is recommended for use at a time. Farmers should also be advised against pesticide mixing unless it is recommended by the manufacturer or technical professionals.

All the farmers interviewed had never attended formal training on pesticide use and these findings were similar to those obtained by Pujara and Khanal (2002) in their study among vegetable growers of Jaishidihi sub-catchment in Nepal. A low level of education and limited professional pesticide application training may lead to poor pesticide handling practices and contribute to increased risk of human exposure through occupation exposure and food consumption (Ngowi et al*.,* 2007; Nonga et al*.,* 2011; Marčić et al*.,* 2011; WHO and IPCS, 2010; Mdegela et al*.,* 2013). Therefore, there is a need for training not only farmers/field agriculture extension staff, but also pesticide sellers; provision of advice by using posters and distributing pocket books illustrated so that a farmer learns to spray downwind and avoid walking towards the spray etc. Farmers need to understand the use of personal protection equipment to avoid inhaling of pesticide sprays and unnecessary body contacts with pesticides.

Knowledge of effects of pesticides and prevention of exposure

Farmers responded that pesticides improve productivity in vegetable growing (90%), could also affect food quality (8%), contaminate non-target vegetation (2%) and surface water (6%). All traders and farmers stated various harmful effects associated with exposure to pesticides on human health (Table 5). The effects stated although reported elsewhere in literature (Grewal et al*.,* 2017) cannot be exclusively attributed to pesticide exposure in this study because general ill-effects were reported as the farmers were unable to associate a specific effect to a specific pesticide. There could be other contributing factors such as harsh environment or other diseases, thus more work can be done to interrogate these responses.

Prevention measures against effects of pesticides were generally well known to both pesticide sellers and vegetable growers as shown in Table 6. However, pesticide sellers mentioned many effects perhaps from experience and information sharing with their customers and/or manufacturers. Pesticide sellers may be prone to prolonged exposure to pesticides in their shops especially those that are highly volatile. Exposure may be enhanced during mixing or repackaging pesticides without personal protective equipment and proper guidelines. There is a need for more educational programs, mass sensitization perhaps through various media platforms to remind the population of the deleterious effects of pesticide exposure.

The impact of pesticides can be minimised by preventive measures such as rational use of pesticides, washing and proper processing of food products, practicing organic farming, use of natural pesticides and bio-pesticides, and strict implementation and amendment

Table 5. Responses on the possible adverse effects of pesticides on human health.

Signs of the Effects	Frequency	Percentage
Traders' responses		
Cancer	33	100
Stomach cramps (pains)	31	94
Brain damage	31	94
Diarrhoea	30	91
Skin irritation	29	88
Infertility	28	85
Allergies	28	85
Weakness	27	82
Headache	26	79
Dizziness	24	73
Vomiting	24	73
Birth defects	20	61
Difficult breathing	18	55
Thirst	15	45
Organ failure	13	39
Confusion	12	36
obesity	11	33
Nausea	10	30
Chills	9	27
Autism	7	21
Excessive sweating	4	12
Chest pains	3	9
Diabetes	3	9
Loss of sensation	1	3
Endocrine complications	1	3
Farmers' responses		
Cancer	328	82
Allergies	176	44
Learning problems	160	40
Nervous system problems	144	36
Weakened immune system	112	28

of pesticide-related laws (Grewal et al., 2017). Training farmers is essential if pesticides are to be used in food crops, simple manuals about safe use, better application methods can be developed and distributed to farmers. Consumers can also be updated about methods that can effectively reduce pesticides residues in vegetables.

Conclusion

In Kabale District, Uganda, cabbages, cauliflower, tomatoes and beetroot were commonly grown and sprayed with cypermethrin, mancozeb, profenofos, malathion, metalaxyl dichlorvos and dimethoate, individually or in mixtures.

Poor pesticide use practices were observed and this could be attributed to the lack training on pesticide use, implying that there is need for a comprehensive program to train farmers on pest control. Pesticide use instructions provided on pesticide container labels usually in foreign languages are very difficult for farmers and pesticide sellers to read and understand the active ingredients present in the pesticides. There is a need for provision of this information in local languages to address this gap.

While traders and farmers contacted in the study had limited information about the various ingredients present in pesticides; they expressed concern about adverse effects on human health associated with pesticide exposure. Preventive measures of the effects of pesticide use such as washing vegetables before consumption, growing vegetables for home consumption organically

Table 6. Responses on preventive measures of pesticides' effects on human health.

Preventive measures	Frequency	Perentage
Traders' responses on preventive measures of pesticides' effects on human health		
Wash the vegetables before eating them	46	92
Training farmers on how to apply pesticides	42	84
Respecting actual timelines for harvesting after spraying	33	66
Grow vegetables for home consumption without pesticide spraying	3	6
Buy unsprayed or organic products	2	4
Farmers' responses on preventive measures of pesticides' effects on human health		
Concerned food quality and government agencies should establish pesticide residue monitoring centres at district level	3	10
Farmers should be trained on how to apply pesticides and make them understand their effects on human life	2	7
Farmers should follow actual timelines for harvesting after spraying	3	10
Farmers should use proper pesticide concentrations as instructed by the manufacturers	1	3
Wash sprayed food before consumption	6	21
Grow fruits and vegetables for home consumption	2	7
Buy unsprayed or organic vegetables or fruits	4	14
Dry the vegetables before consumption	5	17
Peel the outer layer	2	7
Identify vegetables with the highest pesticide load and avoid them	1	3

without spraying and buying unsprayed vegetables were well known but little was known about the modern techniques used to pesticide residues in food stuffs.

While majority of the farmers (84 %) stated that pesticide use as the best option to control pests in vegetables, only 18 % of the farmers could correctly interpret instructions on labels provided on pesticide containers. Some farmers (42 %) mix pesticides to use in vegetables, adherence to post spray waiting periods was haphazard and inadequate in many cases. Thus, there is need for broad based farmers' training on pesticide use in Kabale District, regional and countrywide to reduce risk associated with pesticide use malpractices.

CONFLICT OF INTERESTS

There is no conflict of interest.

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